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Considerations for Bunch Filling Patterns

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The rf buckets for injection and acceleration (28MHz rf) will be numbered from 1 to 360. Each of the two rings will have an independent beam-synchronous event line. The revolution tick† for a given ring defines when bucket #1 passes by the corresponding wall current monitor located in the 4 o'clock sector. (Each ring will have two wall current monitors: one at 4 o'clock dedicated to the rf system, and another at 2 o'clock for instrumentation.) Bucket #1 occurs just after the end of the abort gap and will in general contain the first injected bunch.

The length of the abort gap will be determined by the initial rise time of the abort kickers. Figure 1 shows a simulation of a possible abort kicker pulse with a rise time around 600–700 ns which corresponds to about 18 ± 2 buckets. We shall attempt to time the abort kickers to minimize the width of the gap.

The design of the phase detection system for the rf allows for only certain patterns of bunch-filling. The maximum number of buckets which may be injected into is 120 (ignoring the abort gap requirement); this corresponds to a bunch in every third bucket. Figure 2 shows the various maximal filling patterns which are acceptable. Clearly one of these patterns may be modified by skipping over buckets after selecting a maximal pattern. The numbers at the left of Figure 2 list the maximum number of bunches which could be injected with each of these maximal patterns. In each row the number to the right shows the period of the maximal pattern, e. g., for the 60-bunch scheme, every 6th bucket could have a bunch in it. As an example of a forbidden pattern, this system will not allow for injecting bunches in buckets [1, 4, 8, 11, 15, 18, $\cdots$], i. e., alternating every 3rd and 4th bucket.

It will be possible to mask out certain bunches. One could presumably select the 120 bunch mode and then fill only buckets [1, 4, 7, 10, 121, 124, 127, 130, 241, 144, 247, 250] to have three equally spaced trains of 4 bunches.

Since there are six interaction regions, we must have a minimum of three bunches equally spaced (e. g., buckets [1, 121, 241]) in each ring in order to have beam crossings at all six interaction points. With a single bunch in each ring, only two opposite IR's may have collisions.

Although not required on day-one, we may find that we would like to synchronize the rings during acceleration and injection. With the 60-bunch (minus abort gap) scenario of the design manual, the distance between bunches is almost 64m. By selecting the relative phases of the two rings, it would be possible to make the opposing bunches pass by each other outside the interaction region and thus eliminate beam-beam effects and packman-like-effects during injection and acceleration. Such synchronization may become possible

† The Site-Wide-Name for the revolution ticks are **bsb-revtick** for the blue ring and **bsy-revtick** for the yellow.

after we learn how to ramp the two rings together. A compromised radial loop might be used which averages the radial positions from both rings if the magnetic fields track together within a reasonable tolerance.

With full filling patterns, the requirement of abort gaps will reduce the number of beam crossings at some IR's. For example, consider a 60-bunch pattern with a gap of three missing bunches in each ring. Figure 3 shows which bunches pass at each IR. Here the synchronization has been chosen so that the first bunches (bucket #1) of each ring meet at the 4 and 10 o'clock IR's. Notice that the abort gaps also line up at 4 and 10, but at the other four IR's the abort gaps do not line up. In this example the 4 and 10 o'clock IR's would see 57 beam crossings per turn while the other IR's would see only 54 crossings. This sort of alignment as well as missing bunches and different bunch sizes must be taken into account when calculating luminosities for the various experiments.